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ABSTRACT

This paper considers the possibility and desirability of competency-based education. It examines the present status of behavioral objectives and reviews a recent assessment of most empirical studies on behavioral objectives. It then presents a comparative consideration and assessment of the following teaching models: (1) the impression model, (2) the insight model, and (3) the rule following model. It also discusses a systems analysis of human behavior, specifically thinking. The paper then uses this analysis of learning activity and the examination of the distinctions which can be made between training and education to form some conclusions concerning competency-based education. These conclusions are: (1) a distinction can be made between learning as a training process and learning as new concept formation, (2) training is useful in the acquisition of skills, (3) machines must only present material that one is sure of so that the pupil is left the freedom essential for the formation of "art images", (4) knowledge is impossible without thinking, (5) thinking is futile without knowledge, (6) goals are to be used for focusing purposes only and not to become the overriding concern in education, and (7) competency based criteria are only relevant to training if they are an outgrowth of the individual's own activity. An appendix is attached which contains a chart of the process of planned socio-technical change. (BD)

"SOME THOUGHTS ON THINKING IN COMPETENCY-BASED EDUCATION"

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"SOME THOUGHTS ON THINKING IN COMPETENCY-BASED EDUCATION"*

The purpose of this paper is to consider the possibility and desirability of competency-based education. I wish to present:

- the present status of behavioral objectives
- a review of a recent assessment of most empirical studies on behavioral objectives
- a comparative consideration of some models of teaching: the impression model, the insight model, and the rule following model indicating the strengths and weaknesses of each one.
- a systems analysis of human behavior, more specifically human thinking and indicate some consequences thereof, specifically a cybernetic model of thinking.
- a possible answer as to the possibility and desirability of a competency-based education.

INTRODUCTION

The decade of the 1960's, probably had behavioral objectives as its most discussed subject in curriculum development.[1] With the advent of programmed instruction "it was common...to see such objectives as yet another panacea for America's educational ills" (Doll, 1973). Tied in with behavioral objectives, and representing the development of the 1970's is competency-based education, and performance-based certification. Thirty states presently require competency-based programs for teacher certification.

While the meanings of the terms are not clear we can find definitions that become guidelines for performance-based certification of school personnel. There are definitions which become a guideline. One such definition "means only that the criteria for certification be made explicit, and that prospective teachers be held accountable for meeting those criteria." (Shalock, 1971, p. 431) With this definition, present methods of certification are "performance-based" in the sense that grade point average and course of study and other such requirements must be met by the student. Some additional meanings that are now included in this are as follows:

- "more stringent criteria for knowing than course grades"
- "the performance or specified teaching or teaching related behaviors and/or"
- "demonstrated ability of prospective teacher to bring about desired outcomes...in pupils...or desired non-instructional outcomes...the ability to develop and design a curriculum... or curriculum evaluation study"

(Shalock, 1971, p. 431)

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These "classes of criteria" for certification are referred to as knowledge criteria, skill criteria and competence criteria.

We thus could inquire into the criteria that undergird competency, and who shall select them; whether educational objectives must be framed primarily if not exclusively in behavioral terms; whether education per se represents goal orientation. We can inquire into the justification for specific performance criteria and whether there is a strong or emergent research base. All these have been looked into and there are no easy answers.

It has been stated that: "The long hand of behaviorism retains a very firm grip on a very large number of professional positions." (Scriven, 1973, pp. 442-445) After all, goals, objectives expressed in a behavioral manner are easier to evaluate, do allow for individual differences, are more precise and specific and do emphasize learning more than teaching: (Doll, 1972)

It can be asserted, as Scriven has done, that Skinnerian behaviorism is "the nearest approach to an atheoretical slice of psychology that we have seen". (Scriven, 1973, p. 442) That it is "a philosophical shamble." (Scriven, 1973, p. 432) That Skinner in Beyond Freedom and Dignity is profoundly wrong in his philosophical conclusions. (Scriven, 1973, p. 442) Or that we can, and should, disregard Skinner's verbal taboos and follow the advice to "go out and find the educational procedures and experiences that will bring about a demonstrable[2] change in behavior, of the kind that produces demonstrable benefits. (Scriven, 1973, p. 437) Who could not agree with this? A direct consequence has been the development of programmed instruction, computer assisted instruction, token economy instruction, and competency-based teacher certification.

Yet Scriven is also the one who stated that the only successful program in the use of computers or technological aided instruction is the Edison Responsive Environment. (Scriven, 1970, p. 898) The others have not paid off. As to token economy instruction, even if we were to discover that its use may be successful, it is crucially important to note that most studies in behavior modification do not report investigation of transfer of learning or generalization effects. Programs as that of Bereiter and Englemann which are certainly competency and behavior modification based have now ended and Englemann has recanted his own work of the last 8 years. Note how strange is the English which Bereiter and Englemann tried to teach the children when emphasis is placed on atomistic learning. The child is asked to respond to the question, "What is this?" The required response is "This is a book." Yet the contextually correct grammatical form is, "That is a book." This is a small indication of what happens when "artificial tasks have arbitrarily been invented in order to secure application for principles". (Dewey, 1910, p. 213)

We can point to the failure of Performance Contracting, yet complain that it was not given a fair chance. Other assessments that have focused on some empirical studies of the effects of behavioral objectives on learning have just been reviewed in the Review of Educational Research (Duchastel and Merrill, Winter 1973)[3]. Some of the findings follow.

It is pointed out that

> "a few investigators have turned to research in an attempt to base perceptions of the issue (i.e. the feasibility of using behavioral objectives and the value of such objectives to teaching and learning) on empirical groundsrather than on purely logical/rhetorical grounds...whether or not behavioral objectives are of value or not in curriculum construction, teaching, and learning is really an empirical question."! (Duchastel and Merrill, 1973, p. 53)

The following three main instructional functions that are deemed to be served by behavioral objectives are:

- direction for teaching and curriculum development
- guidance in evaluation
- facilitation of learning

As a means for improving teaching, "empirical research in this area would seem to be open to greater difficulties than it would in the area of learning." (Duchastel and Merrill, 1973, p. 53)

As guidance for evaluation, it is stated that it would "seem implicitly valuable." (Duchastel and Merrill, 1973, p. 54) (Who is on logical/rhetorical grounds now?) Further, it is noted that "although criterion-referenced evaluation may not be amenable to classical statistical techniques, this should be a minimal factor determining its usefulness." (Duchastel and Merrill, 1973, p. 54) This represents the extent of the discussion on evluation.

It is to the third function, an aid to learning, that the authors mainly addressed themselves.

The question was raised whether "communication behavioral objectives have a facilitating effect on their learning?" (Duchastel and Merrill, 1973, p. 54) No simple answer was forthcoming. A number of studies showed facilitating effects and an equal number of studies failed to demonstrate any significant differences.

In summary, it was stated that "the availability of objectives was found to facilitate learning in certain instances, although the generalization of these instances is not easily determined." (Duchastel and Merrill, 1973, p. 57) No attempt was made to segregate in the studies any distinction between what I will later define as two distinctive features of learning, education and training. Subject matter per se did not bring additional consistency to the results. (Duchastel and Merrill, 1973, p. 63) The second group of seven studies at different levels of schooling, "sought interactions between type of learning and availability of objectives." (Duchastel and Merrill, 1973, p. 57) Learning here was categorized as "knowledge or comprehension where knowledge is understood to be the learning of facts and comprehension to be the learning of principles." (Duchastel and Merrill, 1973, p. 57) Precise definitions were often lacking.

In only one study were objectives found to be more effective with one type of learning (knowledge). Furthermore, this difference was

apparent only on the post-test and not on the retention test. Again for problem solving tasks generalizability could not be determined. (Duchastel and Merrill, 1973, p. 59) It would seem that Scheffler may be right, as will be seen later, on the weaknesses of the impression model of teaching.

With the third group of eight studies, the attempt was made to discover interactions between the availability of objectives and certain learner characteristics. With respect to aptitude, there is conflicting evidence although there seems to be an interaction with a number of learning characteristics, which points to the need to restrict any generalizations.

Time factor was looked at in the final category of three studies. It was found that students provided with objectives do not necessarily take less time to learn instructional material than students without objectives. (Duchastel and Merrill, 1973, p. 63)

The final discussion is relevant: "The evidence reported here demonstrates the complexity of the issue, and the many seemingly contradictory results...However...this review has shown that objectives sometimes help and are almost never harmful. Therefore, if the provision of objectives is relatively inexpensive, one might as well make them available to students." (Duchastel and Merrill, 1973, p. 63) (Then further on)..."In future research we should endeavor to insure that subjects understand the meaning of objectives and actually use them while learning. Perhaps even more than a short training session will be required to accomplish this." (Duchastel and Merrill, 1973, p. 65) (emphasis not in the original). "...Future research should seek to clarify (dimensions of specificity) through explicit operational definitions." (Duchastel and Merrill, 1973, p. 66)

At this point questions are in order. Has it been shown that objectives sometimes help and are almost never harmful? Is it relatively inexpensive to do? If the subjects understand the meaning of objectives and actually use them what more needs to be learned?

I need not bore you with the details on operational definitions but must state that such a search as an explicative methodology has profound problems with it to the extent that whole libraries have been written about it.

The above represents a recent assessment of most empirical studies on the use of behavioral objectives. Not only should the questions raised on page one be considered, but also a consideration of prevalent points that may be raised in an open discussion on the effectivness of behavioral objectives should be included.

> We can point to the success in the engineering world of a systems approach, which to some, therefore implies, that we can do the same in social engineering. Yet, that category of specialist is almost non-existent in the behavioral sciences. And we are not educating for such an eventuality. (See Appendix A)[4]

We can point to the lack of success in the last thirty years of clarification and analysis of human learning to the point that today the 1973 NSSE yearbook on "Behavior Modification in Education" leaves entirely open the question of whether this approach has been beneficial. (Scriven, 1973, p. 444)

We can follow William Doll and show indeed how means and ends become dichotomized in an education that is aimed at behavioral objectives (Doll, 1972). We can emphasize the dangers such a dichotomy entails and its narrowness. It draws attention away from examining consequences, and hinders the intelligent creation of purpose. Dewey showed crucial deficiencies in this view and stated: "There is a strong temptation to assume that presenting subject matter in its perfected form provides a royal road to learning." (Dewey, 1916, p. 220) He offered "the alternative, in which goals, activities and behaviors of the student are not determined for him, but rather by him." (Doll, 1972, p. 323) Dewey's model[5] emphasizes the process of experiencing, in the sense of both doing and receiving the results of doing, which become focal. (Doll, 1972, p. 323)

Note that the emphasis here too is on experiencing, as in Skinnerian aims. But, what is being experienced is crucially distinctive. The ends of the activity are not determined a priori and separate from the activity itself! "Ends arise and function within action". (Dewey, 1957, p. 207)

We can go the humanistic route and decry the culture wide preoccupation with efficiency and public performance, and note with apprehension that accountability reduces education to teaching measurables.

We must, however, point to the unacceptable figure of 40% of inner city school children, grades three to eight, of Philadelphia, who are at the 16% level nationwide in reading achievement. This figure is up from 31% in 1967.[6]

This can be countered by indicating the demographic link in these scores and quoting a significant study excerpted in the April Commentary magazine on "Black Progress and Liberal Rhetoric". (Wattenberg and Scammon, April 1973) We find that today, while there is a high percentage of functional illiteracy in schools, a majority of blacks have entered the middle class. That the median school years completed by blacks in 1940 was 7.0 years; in 1950, 8.6 years; in 1960, 10.8; and in 1970, 12.2 years. That the college gap between blacks and whites narrowed. And, that the large increase of blacks on welfare rolls is accounted for by the addition of women heading families who for the first time had access to welfare funds as an alternative life style to living with men, just as white women have had such an alternative for better than thirty years.

The sad fact is that the liberals' denial of these and other accomplishments (see the full article) does not provide the pressure on the administration to do more, as the liberals thought it would, but provides the justification for the conservatives to scuttle valuable school programs.

We can point to the fact that we now have about 5,000 graduates in Early Childhood Education, yearly, on a nationwide basis, and the need is for 23,000 per year at least to 1980.[7] And, who can be against "upgrading the skills of staff responsible for the education and development of young children".[8]

But must we then accept that: "The credentials of the Child Development Associate will not be based solely on academic courses, possibly unrelated to early childhood education and development. Rather emphasis will be placed on individualized training and careful evaluation of each person's demonstrated ability to assume primary responsibility for the education and development of a group of young children in a Head Start, day care, or other preschool setting."[9] (emphasis not in the original)

The Office of Child Development is not alone in asking for performance based or competency-based teacher training or certification. The USOE report Task Force 1972 Committee on National Program Priorities in Teacher Education (CNPPTE), The Report of the Fleishman commission, and the Regents Statewide Plan for the Development of Post Secondary Education also ask for it. The USOE report proceeds from the idea that we do not yet know what the competencies are nor how to measure them. (Shanker, 1972)

Dean Rosner headed the committee which prepared the USOE report. "Criterion levels" which were developed included the following:

- the assessment of the teacher's knowledge
- the appraisal of a teacher's actual skills
- measurement of pupil achievement, after a short period of time and a longer period of instruction

The conclusion of the Report is that teachers should be held accountable for changing teacher competency, teacher behavior, and (that) pupil performance is not the criterion for teacher certification. (emphasis not in the original)

Here, we need to ask: Isn't the whole effort to establish competency-based programs and to develop behavioral objectives generated so that pupil performance be enhanced? (supra, p. 1)

The problem of pupil performance not being the criterion for teacher certification is not only due to technical difficulties, but also arises on the basis of a logical analysis of the relationship between teacher education, teacher certification and pupil

performance.[10] After all it has been a very long time in civilized society that a doctor has been put to death if the patient did not recover. In the case of the teacher, consider the conditions under which his job is often performed: non-supportive home environment, lack of adequate resources, non-support by the community, etc.

We have already pointed out in the above (page 3, 5, 6) that accountability is a crucial issue in education. However, a plethora of literature (Broudy, 1972 and Leight, 1973) is indicative of some of the difficulties that accountability presents.

Let me digress and note that in fields such as physics and biology and generally the natural sciences, we are now tending to a systems view, a field view, to one no longer atomistic. One would think that the social or behavioral sciences would learn from the natural sciences. Apparently this is not to be. There are those in the social/behavioral sciences, particularly psychology, and in the more applied areas like education, who are still thinking that they are forging ahead to a more perfect world, by assuming that knowledge can be acquired by a subject upon presenting it in sufficiently small elements, in a pre-determined order of pre-digested form. All this notwithstanding the stated belief of a conceptual schema such as general systems theory.

If we have learned anything from Dewey, we should have learned that structure cannot be segregated from content. Behavioral objectives segregate the content of knowledge from ongoing inquiry.

This concludes the introduction in which there has been an assessment of a review of recent empirical research on the use of behavioral objectives in learning and a consideration of points which can be raised in a discussion of behavioral objectives. Much that was presented in the introduction can be fleshed out and considered, each in turn. However, in order to get a possible answer as to the possibility and desirability of competency-based education, I wish to present:

- a comparative consideration of some models of teaching: the impression model, the insight model, and the rule following model indicating the strengths and weaknesses of each one.
- a systems analysis of human behavior, more specifically human thinking and indicate some consequences thereof, specifically a cybernetic model of thinking.

I. MODELS OF TEACHING[11]

THE IMPRESSION MODEL

Origin of Knowledge....the impression model pictures the mind as a receptor and sorter of external impressions.

The philosophy of John Locke represents the empiricist variant of this model. It considers knowledge as a result of an input by experience from which sensations and simple ideas are derived and upon which reflections produce complex ideas. These reflections or operations of the mind are perception, retention, recall, discerning, comparing, compounding, naming and abstracting.

Another branch of the impression model is the verbal variant. In addition to sensory experience, language also is impressed on the mind. There are both sense data and verbal patterning. A stored accumulation of statements serves as the base for future utterances. This verbal variant is closely aligned with behaviorism. This is the emphasis in competency based instruction.

Methodology....the impression model leads to training of faculties which are assumed to exist in the mind, i.e., to "educate" means to train the mental powers of the mind mentioned above. The job of the teacher is to provide training in these operations and also one of selecting and arranging experience. Therefore, in effect, the control of the organization of knowledge lies with the teacher.

Aim of Education....the impression model is atomistic. The aim of education is for the learner to put together discrete elements, given by experience, vis-a-vis the structuring efforts of a teacher.

STRENGTHS

1. It is grounded in experience.
2. It provides for an appeal to experience to substantiate ideas.
3. Mind is a function of its particular experiences and is capable of increased growth with experience. Richness and variety of the child's experiences are thus important considerations in the process of providing for the child's education.

DIFFICULTIES

1. Unable to account for new concepts and actions which go beyond previous experience.
2. The field of Psychology has expunged the notion of training of specific faculties of observation, recollection, willing, thinking invariant with subject matter; this approach has been dropped by psychology on empirical as well as theoretical grounds.
3. The simplicity approach is a relative not an absolute concept and reflects a particular way of analyzing experience; this approach is not given, it is made.
4. Implicit conception of growth of knowledge is false; knowledge is not achieved through any standard set of operations for the processing of sensory particulars. Knowledge is first and foremost embodied in language and involves a

conceptual apparatus not derivable from the sensory data, but imposed by them.

5. Approach does not take into account that knowledge involves theory and theory is not simply a matter of generalizing the data.

6. Approach to the process of learning does not consider that the child gets not only sense experiences but the language and theory of his heritage in complicated linkages with discriminable contexts.

7. Verbal variant:

   A: to store all accepted theories is not the same as being able to use them properly in context;

   B: does not imply, even with a correlation with sense data, an understanding of what is stored, nor an appreciation of the theoretical motivation and experimental evidence upon which the sense data rest.

8. Fails to make adequate room for radical innovation by the learner.

THE INSIGHT MODEL

Source of Knowledge is a matter of vision, hence cannot be dissected in sensory or verbal units.

Methodology...Vision can be stimulated or prompted by what the teacher does. Vision is the difference between storing and reproducing learned sentences, and understanding their basis and application. Teacher's statements are instrumental to the student's own search of reality or vision, emphasis is on cognition, or insight, or vision.

Aim of Education is to allow for the occurrence of continued insight.

STRENGTH

1. Considers new knowledge, innovation and understanding.

2. Knowledge earned by student's own effort, and first-hand inspection of reality is important.

DIFFICULTIES

1. Concept of a vision of reality is too simplistic. No room for rational or principled deliberation, for argument, for critical judgment, for appraisal, for weighing of evidence, for appeal to principles and decision-making.

2. Model is static

3. Knowing is more than being informed, or than storing information.

4. Individual insight into the meaning and use of public knowledge.

3. Too cognitive an emphasis. Insight:
   - does not necessitate habits of proper execution.
   - fails to consider character and attitudes and dispositions.

   i.e. no role for concept of principles, or rational or moral conduct.

4. Fails to cover development of natural sciences as well, since science is a living tradition composed of demanding principles of judgment and conduct.

THE RULE MODEL

Knowledge...involves capacity for principled assessment of reasons bearing on justification of the belief in question. Growth of knowledge is mediated by general principles definitive of rationality.

Methodology...knower evidences autonomy by innovation, by constructing fresh and alternative arguments. Teaching is not propaganda, not conditioning, not suggestion, not indoctrination.

Aim of Education...pass on traditions of principled thought and action that we ourselves acknowledge as fundamental, general and impartial. Develop character in the broadest sense. Student achieves learning while his integrity and capacity for judgment are respected.

STRENGTH

1. Insight is not an isolated momentary or personal matter, it is not a personal interaction between teacher and student. Insight mediated by general principles definitive of rationality (reasons, consistency) et al.

2. Accounts for moral, or principled behavior if such behavior is rule bound.

3. Accounts for both tradition and innovation.

4. Respects student's intellectual integrity and capacity for judgment and commitment to freely choose a set of principles.

DIFFICULTIES

1. Categorical imperative of Kant is being replaced by a "rationality" imperative i.e. no guarantee that rule following behavior will take place.

2. New concept formation involves the dissolution of the old logic and of old principles and makes for a many-valued logic and principles. Teaching must somehow reflect this.

3. Moral behavior may not be rule-bound; i.e. know rule but do not follow it.

4. Accounts for innovation but not discovery.

5. If principle is self-contained, i.e. separated from application, principle becomes fossilized and rigid.

THE RULE MODEL (Continued)

STRENGTH

5. Supplements impression and insight model:

   A. reflects the impression model strength, the cumulative growth of knowledge in its public sense. However, not by storing it piecemeal in learners.

   B. reflects the insight model in that knowledge is preserved if one succeeds in transmitting the live spark that keeps it growing, the insight of each learner's effort to make sense of public knowledge in his own terms, and to confront it with reality.

DIFFICULTIES

6. Does not account for change in behavior i.e. can "know" nutrition but not apply it.

II. SYSTEMS ANALYSIS AND HUMAN BEHAVIOR

A CYBERNETIC MODEL OF THINKING OR A FEEDBACK ANALOG TO THINKING AND SOME CONSEQUENCES

Let us now consider the following symbolic model. (Steg 1962, 1969, 1971, 1972)

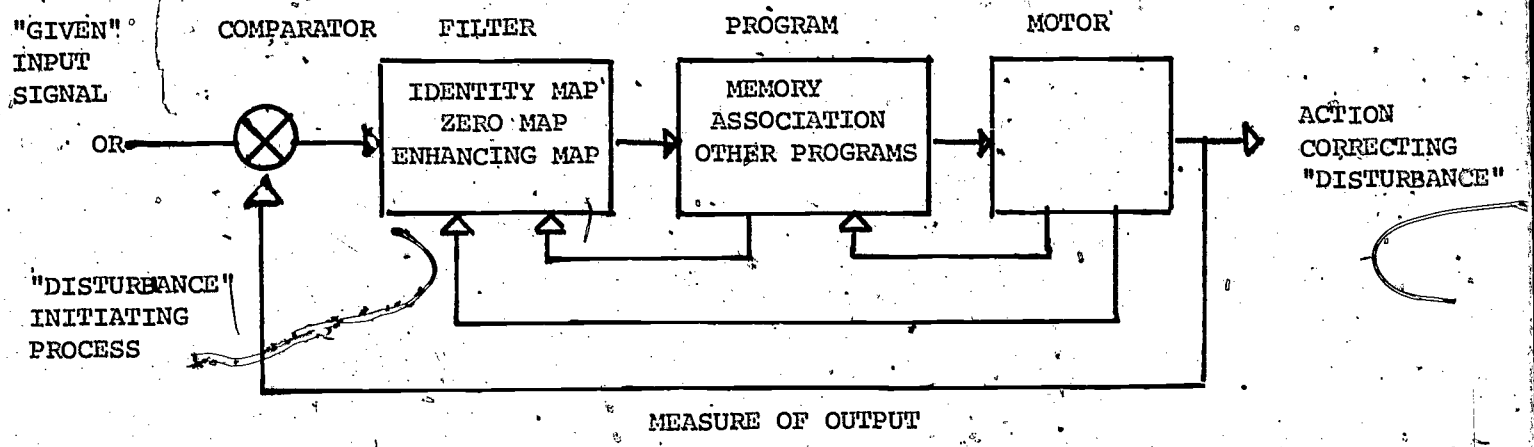


Figure 1: Transfer Function Signal to Control

The model above will be considered under certain restrictions which seem desirable for simplicity but without significant loss of generality. The diagram is seen to include a major loop and a minor loop relating any two of the components; for example, the effect of the filter may directly be modified by the motor element with or without intervention of the program element. We shall consider here, however, only the major loop, without loss of generality or significance, we believe.

Relationships may be established in the following manner. The elements in the feedback loop may be considered, analagous to mathematical constructions, as a set of transformations mapping input spaces into output spaces. Thus, in the major loop a disturbance enters the comparator (a device which compares the output and the input). The output of the comparator is the net error to be acted upon and is measured against the feed back performed action signal, noting the degree of congruence. This forms the input into the set of mappings forming the filter. The set contains:

(1) the identity map (where previous experience results in reflex behavior),
(2) the zero map (where no program is initiated - resulting in total rejection, possibly due to habits, imperatives of social and individual kinds, biases, intolerances, commitments, et al),
(3) the enhancing map, where some significant aspect of the environment is emphasized, forming an art image,
(4) other transformations.

The qualitative preeminent nature of the action is now determined by the filter. When neither reflex action nor rejection takes place, the set of programs, which includes a program for making additional programs as required, contains at least these elements:

(1) memory
(2) association mechanism
(3) other programs

The program element now operates on the transformed incongruity to select the proper programs for the motor element. The action is performed and in turn fed back to the comparator repeating the cycle until satisfactory performance is obtained. The loop operates on information (signals) flowing in the direction of the arrows.

We thus have a model which contains quality as an essential element and operates pragmatically as a closed self-organizing loop. It accounts readily and trivially for teleological processes like problem solving, "planning", and mechanistic behavior. It allows for an infinite variety of awareness-cognition-reaction-feedback-systems. (A compilation of definitions of terms derived from the model which are in common use in the fields of philosophy, education, and other fields can be found in Steg 1967, 1972)

ADAPTIVE-ADAPTING BEHAVIOR

Modern computing machines show that the results of the activity of the mind are not particularly different from those of all reality--i.e., can be achieved by non-mysterious operations. Computers perform a considerable variety of operations which previously could only be accomplished with the aid of the human mind. For instance, a machine called Cyberton (produced by the Raytheon Co.) is said to be capable of learning by trial and error. The machine has a memory device, an association mechanism, and a decision-making element. In operation, it can modify its memory in order to obtain a correct answer to a problem; and if that does not occur, the machine is fed a weakened signal of the correct answer. In time, with the aid of a supervisor (possibly another program tape), the machine will "learn" and obtain a limited training or assimilate experience.

The training of a machine and machine-learning suggests the type of mechanism involved. This machine caused a modification of memory; thus an individual system will modify previous memory as a result of training and acquire a new memory.

It is safe to assume that, as with the laws of physics, the laws governing control systems apply equally to animal, man or machine. In the language of the systems engineer, this is a closed-loop control system. The control system pattern consists of (1) an input signal that triggers some action, (2) a feedback signal of the result of this action to compare with the input signal, (3) a closing of the loop, a summation of the two signals and (4) effective action to counteract this summating signal. A persistent residual signal can be made to affect memory which results in "learning". In a control system, work is triggered as a result of an actual error input[12]. The error is essential to the activity of any control system. These mechanical patterns apply equally to automatic machinery, animal behavior, and man's everyday automatic activity.

It is emphasized that the subject under consideration is automatic activity of man, animal, or machine.

The mechanism involved in this automatic activity is by nature an adaptive control system. For instance, a machine that automatically regulates the temperature and humidity in a given area is of the adaptive type, since it uses the energy under its control to satisfy the requirements of its environment-sensing elements and adapts the system to eliminate the disturbance as sensed. A more sophisticated automatic control might have a variety of energy sources under its control to perform all kinds of automatic functions. The control system described will remain automatic even though a change in memory can occur under certain conditions; (i.e., a change in the setting of the thermostat). The pattern of an error input which automatically triggers use of controlled energy to cancel out the disturbance sets limits to the degree of freedom of this type of control.

An important deviation from the automatic pattern occurs when the automaticity of the system is eliminated. Non-automatic activity will not necessarily be subject to the adaptive nature of the control system and trigger its energy to cancel the disturbance.

With the automaticity eliminated the response to a disturbance is chosen after the disturbance has been analyzed as to its source, the energy involved in the disturbance, the possible response and resulting consequences, including analysis and assessment of energy sources and energy balances. In other words, understanding is replacing automatic response.

Surely a machine that automatically regulates the temperature and humidity in a given area, controlling the environment of that area, or machines (built by man), with effector systems which regulate all kinds of things in their environment, from the acidity of chemical solutions to the polishing of machine parts, do not follow the pattern of non-automatic activity. To regulate the temperature in the non-automatic fashion is to go through the discovery of the laws of physics and understanding of heat and cold and using elements outside of man's own physical structure (mechanism) and finally to build the automatic temperature regulating control for man-made environments at home or factory. The automatic control is adapting nature. It adapts elements external to its own system. The heat that is controlled by the automatic controller is neither understood conceptually by it, nor is the activity conceived by the automatic controller.

Let us examine the non-automatic control mechanism. Since it is essential that the error signal be acted upon if no automatic triggering is made of the system energy, it is necessary to introduce a source of energy other than the one subject to automatic triggering, or a power capacity beyond that controlled by the mechanism. Being outside of the control mechanism this new source of energy is forcibly the same as the source of the error or part of the environment. The new system, which is non-automatic, does not follow the adaptive pattern, but makes use of energy in the environment. In other words, it will make the environment adapt to the system instead of causing the system to adapt to the larger environment.

To recapitulate, an adaptive control system is subject to the effect of the environment on its sensing elements and has no freedom to control the effect of the environment on its sensing elements. It can only adapt the system by using its own energy to satisfy the requirement from the environment conveyed through the sensors.

DISTINCTION BETWEEN TRAINING AND EDUCATION

The distinction to be made between an adaptive system of controls and one that would modify the environment has far-reaching meaning for the application of control theory to human activity.[13]

Thus in control mechanisms and computers the system is of an adaptive nature. This means that, whatever the disturbance of input to the system, the response follows the pattern of triggering an action involving system power that leads to an adaptation of the system to eliminate any differential between the fed-back signal from the output and the original input signal. The response is automatically proportional to the input signal in an adaptive system.

Opposed to this is the human ability of adapting an environment by means that extend human reach in a specific fashion, including in the process the use of tools, machines, and psychological, socio-political, economic and other instruments. Specifically, the human mechanism directs the signal-triggered action with a view to the adaptation of the environment in eliminating the differential between the fed-back signal resulting from the modified environment and the original input signal. The mechanism involved in the latter system or disturbance is subject to the filter of intelligence, thus creating an art image of the environment to serve as a blueprint for the adapting process. In the adapting control system, the response to an input signal is not necessarily proportional to the input. The system involved in specifically human activity is operable only when an action is triggered to adapt the existing (given, objective) environment to an art or dream image. Thus the performance here depends on education and not training alone. Training involves learning some specified pattern of behavior, be it equilibrium on a tightrope or chessplaying, while education is new concept formation. The result of education is creativity, while the result of training is performance involving skill.

As defined by Dewey, art is "to select what is significant and to reject by that very same impulse what is irrelevant and thereby compressing and intensifying the significant."[14] We should add to the statement that both the "significant" and the "irrelevant" are dynamic concepts that continuously change position. Because machines have only automatic, adaptive responses, and thus have built in "significant aspects," "creativity" is impossible.

Education is the phenomenon which initiates a control activity, triggered by the element of relation, association, or construction that appears, for example, when an artist produces an image unlike the one achieved by a camera. (It also appears in all scientific discovery, as a change from the accepted previous concept.) In other words, education centers on the "art" created image and its involvement in control system activity.

It is important to note that a changed concept occurs not externally but as a result of a change within the thinking mechanism,[15] within the system. The computer or the animal is fed the error or input by the operator

or by the environment; the automatic sequence from that point in time on is fixed by the nature of the mechanism.

The machine or the animal lacks the broad ability available to man to change the input into the mechanism because either the machine, or the animal, lacks man's choice[16] to modify the existing (given, objective) environment.

Assuming the foregoing to be correct, I suggest that we must distinguish between learning as a training process and learning as new concept formation (development and growth).

CONDITIONING VERSUS CYBERNETIC CONTROL

It can be suggested that "the presentation of a stimulus, response and reinforcement" is training, useful in the acquisition of skills; that it enlarges the automatic control mechanism field of activity. However, the distinction to be made between cybernetic control and reinforcement control delineates clearly the difference between sensory feedback and the feedback concept of knowledge of results or reinforcement, and has far-reaching meaning, both theoretical and applied, for the application of control theory to human activity.

The principle of feedback-control was recognized by training psychologists more than 25 years ago. Its introduction as a formal behavioral concept dates back to 1948, when Wiener published his book Cybernetics. His term. cybernetics, called attention to the study of human control mechanisms and the principle of feedback control.

Feedback control visualized an elementary system of control by which the sensing elements of an organism can obtain information and feed it back internally for guidance of its operative motor nerve centers. Such feedback was a commonplace of the physiologist long before the engineer found common ground with him in "Cybernetics". This principle of steersmanship by feedback has undoubtedly played a very important evolutionary role in animal life.

Feedback mechanisms are characterized by the use of the measurement of some physical quantity to control a motor mechanism that in turn adjusts the magnitude of the measured quantity to bring it to a predetermined desired value.

Behavioral scientists have indicated a rather widespread acceptance of the principle of feedback. However, feedback and knowledge of results is being used synonymously, and knowledge of results is thought to function as reward as well as information. In the Psychological Abstracts feedback is indexed as "See also knowledge of results, Reinforcement". One can thus see why many theorists took the term feedback to mean reinforcement.

They assign the feedback signal reinforcing properties; the smaller the magnitude of the error, the greater the reinforcement value of the signal. It is understood then that the response that minimizes error is presumably strengthened or learned.

It has been observed experimentally, that providing knowledge of results, rather than reducing or withholding knowledge, does lead to more effective learning. And, it is true that immediate knowledge is more effective than delayed knowledge. But, this does not automatically enhance efficiency of performance and learning. Yet, it is generally assumed that learning can be enhanced if it is followed by reinforcement.

In other words, dynamic sensory feedback provides an intrinsic means of regulating motion in relation to the environment while knowledge of results given after a response is a static after-effect which may give information about accuracy, but does not give dynamic regulating stimuli. Dynamic feedback indication of "error" would thus be expected to be more effective in performance and learning than static knowledge of results.

Furthermore, the efficacy of reinforcement assumes an active need or drive state while, feedback theory assumes that the organism is built as an action system and thus energizes itself. Hence, body needs are satisfied by behavior that is structured primarily according to perceptual organizational mechanisms, and require programs that communicate.[17] We can now judge why reinforcement of a child turning his head to the right in order to suck from a bottle of milk takes hundreds of tries and Bruner's baby with the $20,000 pacifier takes only a few tries (maybe four) before he learns to focus a picture of his mother, and, he isn't even hungry.[18] We can now understand why the Responsive Environment is thus far the only successful mechanically based programmed instruction (Scriven, 1970).

Systematic transformations of sensory-feedback patterns are affected by the use of tools, be they symbols, socio-psychological, economic, or other instruments. Opposed to this, reinforcement theory describes learning as due to the effects of reinforcements that bear no systematic relation to the different kinds of behavior learned.

TRANSFORMATION OF CONTROL - A SUMMARY

A theory of behavior organizations should enable us to conceptualize an orderly progression from relatively simple overt response patterns seen in very young children to the complicated skills, symbolic responses, and other abstract thinking that an individual can exhibit. These human processes can be analyzed in terms of systematic transformations or sensory-feedback patterns. Implicitly this denies the general validity of association and reinforcement models.

What appear to be different types of thinking may actually be considered as differences in patterns of feedback control. There are no distinctive categories in learning except in a general descriptive sense.

(1) Verbal learning and instrumental learning differ because the systematic transformation of closed-loop regulation behavior are different in these two areas.

(2) Instrumental learning and unaided psychomotor learning differ since the use of tools and machines involves spatial, temporal and kinetic transformations of feedback. This in turn changes the pattern of control.

(3) Psychomotor learning incorporates the feedback mechanisms of manipulative movements.

(4) Orientation learning involves integration of the larger transport and postural movements of the body into a more general pattern of control.

Classical conditioning differs from orientation learning because the subjects are restrained and deprived of much of the varied sensory feedback used in normal adaptive responses. Feedback theory can account for a variety of behavior (from relatively simple overt responses to complex overt and symbolic skills). Thus, cybernetic research in learning may well provide a framework for understanding and studying a variety of learning patterns.

To summarize: Use of linear programs (including branching) in teaching, deliberately limits the media of communication, the experiences of the student and thus the depth of understanding that he achieves. We suggest that instead the student be provided with a broad context of experience by resorting to all of the activities and to all of the communicative media at our disposal. This includes verbal and non-verbal material. Thus the student learns by responding to the perceptual organization of his environment.

TEACHER-MACHINE RELATIONSHIP

Mathematicians and music teachers alike deplore the fact that the student's brain cannot be disconnected from the mouth or the hands for acquisition of manual skill or the multiplication table. Not only should the brain be switched out, but perhaps also the teacher, who might be replaced by a program.

There are two elements that are involved in the teaching situation: teacher and pupil or programmed machine and pupil. In the case of teacher and pupil it is the teacher who supplies all the material. Whether the material is used as training material or growth material depends on the pupil. Whether it is the machine or the teacher who supplies the material the question is a question of efficiency and not of quality. The quality of the material can be poor or excellent be it with the teacher or the machine. But the ability of the human being to induce growth and development in another human being cannot be mechanized; what is required is a closed-loop behavior between the teacher and the pupil until the pupil has produced growth and change in the input, the teacher. In other words, the teacher who would enhance growth in a pupil has to be growing and changing and be free to develop as the pupil grows and changes. Hence, communication and not transfer of information.

Dewey's definition of thinking as "the intentional endeavor to discover specific connection between something which we do and the consequences which results, so that the two become continuous,"[19] or more briefly, "the intentional noting of connections,"[20] is of a descriptive nature only. In reality, thinking is an analysis of doubts, although understanding must precede thinking. Thinking does not take place first, then to be followed by understanding. Understanding as opposed to habit

or knowledge implies disintegration of existing concepts, the creation of doubts which will lead to new concept formation. If understanding of disturbances of the condition does not precede then enhancement cannot take place.[21]

If the adapting control process "filters" disturbance or input signals in the closed-loop servo-sytem which controls human action, education is then taking place.

The servo-mechanism of the human control system continuously develops and grows as thinking develops and grows. Inquiry and correlation of experience are tools used in this process of education; they are elements which trigger the controls. As for experience itself, we can no more know what particular "experience" will do to education than what a "pencil" will write. Experience, of course, is a prerequisite, just as one needs a pencil or something to write with.

Any realization of something being wrong is a discovery. It contradicts the previously assumed satisfactory order. Anything that has been logical up to this point becomes illogical, becomes wrong, becomes an error, and will make room for the elimination of error--for a new logic--for the "ought" instead of the "is." This realization that something is wrong (which initiates the process) is a prerequisite required for new concept formation. There is a difference between man and animal or man and machine which is made to simulate man's behavior. The computer essentially accomplished its function by operating on a multitude of types of problems with techniques for solving them. Thus a problem fed into the computer in a sense triggers the answer that was originally built into it. But, to reiterate, human problem solving is a matter of education and growth. It creates or formulates problems and at times their solutions.

A machine that would simulate man's achievement is a machine that is in complete communion with nature. To be in complete communion with nature one must understand it in all its aspects, every element of it, living and growing as part of the expanding universe. Thus, one would need an equal to man and his interrelations with his environment and the combination of his dominance of it and subjection to it.

As long as the machine lacks the means of communicating and appreciating reality and the outside world, it is bound to a "logical" system limited to the factual knowledge that formed the basis of its "logic." Knowledge is impossible without thinking, and thinking is futile without knowledge.

Let us make a final plea as humans. It refers to Art with a capital "A." Dewey defined art as something no one can teach.[22] Nobody can teach an enhanced, a distorted or artificial view of things. One cannot make a person distort or enhance something in a way that one does not himself know how to distort or enhance. And yet such oblique or surrealist views and disorderly processes seem to be the essence of education and creativity. Hence, the question: What can be done? What can a person, what can a teacher do which is distinctive from what an instructional machine can do?

As long as we realize the limitations of the teaching mechanism, this

mechanism can be artificially constructed. After all, the basic characteristic of the human species, namely, the ability to make use of tools which throughout history have become more and more involved and complicated, points the way of civilization to the use of tools in the teaching professions. Engineering skills can be applied to the teaching "mechanism." However, to apply such skills to the domain that is outside the domain of teaching, to the domain of culture, or Art and learning as development and growth, would be equivalent to an attempt to construct a mechanism which would guide the brush of Rembrandt, the pen of Shakespeare, the chalk of Einstein, or the chisel of Moses.

"Civilized" teaching, on the other hand, is programming and teaching through teaching machines--because it frees man from the chores that are done more efficiently by tools.

It is important to remember that whatever has been taught by a teacher of a machine is only going to bear fruit if the pupil is left the freedom essential for the choice of the "significant". The question now arises: where is freedom of choice greatest, with the machine or the teacher? While the teacher may or may not have an axe to grind, may or may not have specific physical or mental conditions that one day will make his performance different from what it usually is, a machine has a reliability that is undeniable.

But we must preserve this freedom of choice; a choice whether to listen to a teacher or not, take or leave whatever we wish to take or leave. To preserve this freedom is the job of the teacher. Teachers must show that "progress" lies only in the freedom of choice, in enhancing the significant, in Art. Then the machine becomes what it must be--a useful tool. A teacher can be subject to an absolute bias (Kant's imperative or Moses' right). A machine is a programmed tool without the charisma of a teacher; the bias of its programmer is less likely to affect the pupil than direct contact with the bias of a teacher. As long as we realize that we are not teaching anything but the use of elements of civilization, that education is the result of the individual's free choice, and that education cannot be taught, then teaching (learning) machines are indeed good tools.

Learning is the possibility of going outside of a frame of activity. The difference between man and animal or machine is specifically that a machine that has "automatic" activity has, of course, been programmed to so act. It can automatically perform activities which it was designed to perform. An animal or man can also be programmed, i.e., the responses are limited to the programming or designing, just as in behavioral terms persons automatically respond as experience, reinforcement or "programming" has determined that they shall. The responses are the result of training. A Nazi party man is as programmed as a machine. The learning in this case is programmed, hence automatic. But it is questionable whether one can train all men. The possibility of training may be inversely related to the distance the individual has progressed from the animal state.

An adapting control is an outgrowth, a development and a modification of an adaptive control sytem.

However, "significant aspects" resulting from scientific inquiry, value judgment, philosophy, etc., imposed on human society and forming goals to be achieved by relevant authorities approved by the people, may become the overriding concern and make the end govern the means, eliminating or restraining choice. Therefore, the most important theme of our society may be the belief that we must at all costs retain the right to opposing views and goals.

It is remarkable that the history of science or exploration abounds in discoveries far afield from and infinitely more important than the original goal. Goals and objectives may be fine, but only for focusing purposes and to help us broadly direct an effort along a wide front.

CONCLUSION

An attempt has been made to analyze learning activity as subject to controls and to laws of control systems. Distinctions are made between training (assimilation of previous experience) and education (growth and development, new concept formation).

"Scientific psychology" is based on a cause-effect model where stimuli act on organisms to produce responses. Feedback theory shows how such a model fails and how we can correct our concepts of organized behavior (Powers, 1973, p. 350) It is already known that responses are dependent on present and past stimuli in a way determined by the current organization of the nervous system. But what has been totally neglected is that "stimuli depend on responses according to the current organization of the environment and the body in which the nervous system resides". (Powers, 1973, p. 351).

A comparative consideration of some models of teaching points to serious deficiencies in a model which is solely a competency based approach to education.

A system analysis of human thinking, a feedback analog to thinking, implies that while we can train for adaptive behavior (where the individual adapts to environmental requirements) and while training is a necessity in education, it is not sufficient nor is it the more interesting component of human behavior. It is adapting behavior, where the individual changes the environment to suit his own requirement, that is the interesting behavior. This necessarily involves having the freedom of choice to enhance significant aspects of the environment to be acted upon. The cybernetic model allows for infinite alternative system capability.

A competency-based education is thus a contradiction in terms. Competency based training? Yes! But then we must be able to allow the child to take or leave what the teacher or the teaching machine or the programmed environment is offering.

It needs to be reiterated that in behavior modification, transfer and generalization effects are mumbled about. Furthermore memory is highly degradable. We have known this since Thorndike's days. Additionally if one is mostly interested in behavior and its external conditions one runs the risk of not focusing on the inner man. And it is here that we must raise the question about education for moral behavior.

Moral judgments and moral behavior, must be defined as that which will work in the absence of any possible reinforcement. Otherwise, what has been accomplished? It cannot be indoctrination or conditioning, or suggestions, or propaganda (Scheffler, 1966); it is a matter of education for human understanding. (Steg, 1964)

There are some further problems:

Emphasis on competency based programs does present the problem of conformity, and/or capriciousness in choices of goal behaviors.

Training in behavior-management techniques may lead towards more effective practice. As for education, it cannot even begin to make a dent in it. Education takes time, not just a year or five years, and it takes resources. All too often schools have been financed at the expense of teacher salaries.

We try to have as many field experiences as possible involving children. We say that it is simply not enough to go through texts about child development, that opportunities to observe and interact with children is absolutely crucial, because we know that this is an area where theory is relatively unreliable, as might well be said to be the case with developmental psychology of the early years. Shall we now turn around and say we know enough to categorically demand a competency-based program?

Alternately while we must emphasize that incompetence results in poverty, that incompetence makes for unemployability, that training makes for competence, however, performance outside one's interests and beyond one's competence makes for unhappy children and feelings of alienation, rebellion or apathy.

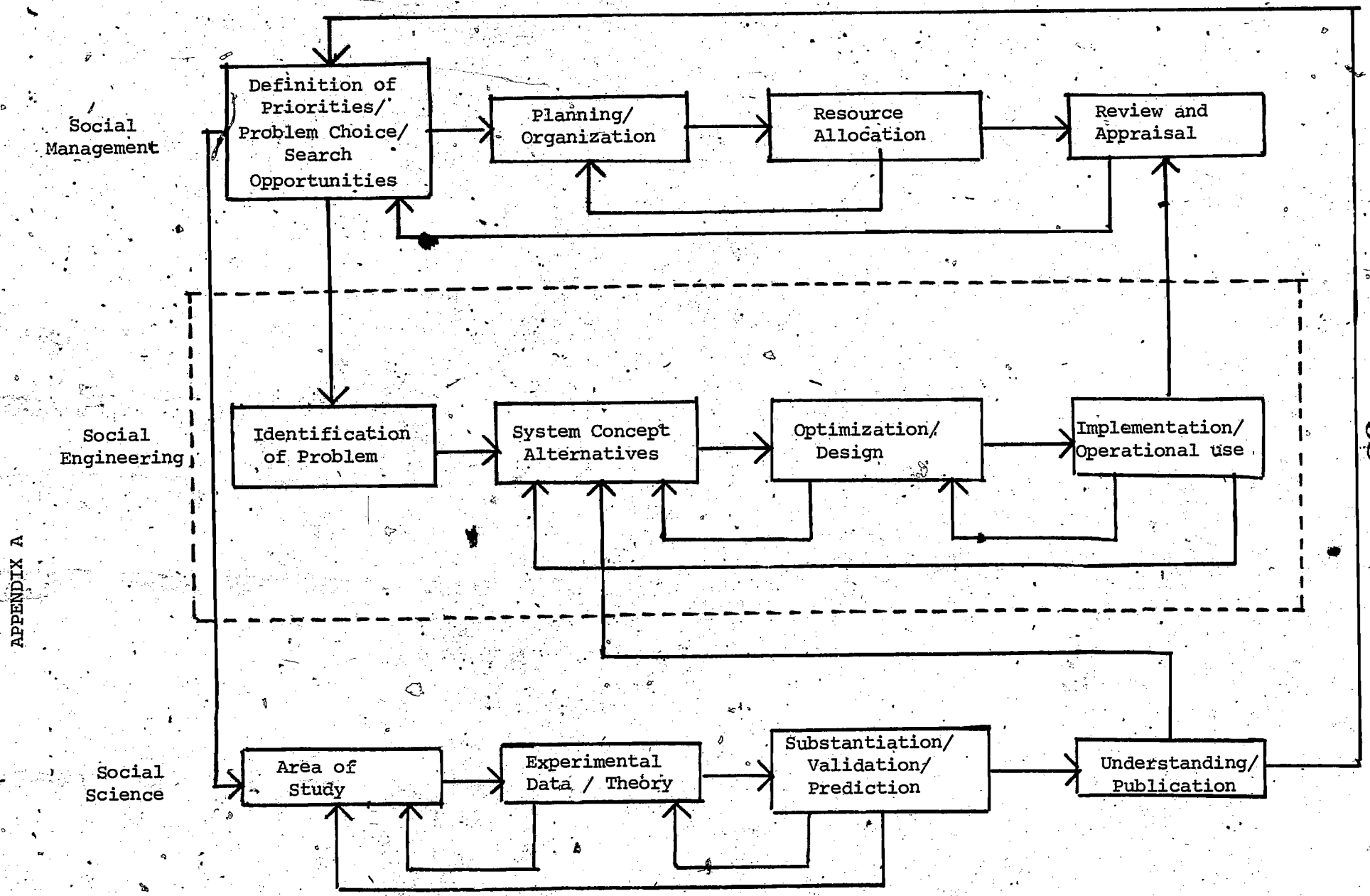
All training is but a means, a tool. But education cannot be confused with training. Education has no end beyond itself, and growth and development no purpose other than more growth and development. Training is not subordinate to education. It is a tool in education and which if dichotomized.... As Dewey so aptly stated: "...for the most part, adults have been given training rather than education...original plasticity is warped and docility is taken mean advantage of. It has been used to signify not capacity to learn liberally and generously, but willingness to learn the customs of adult associates, ability to learn just those special things which those having power and authority wish to teach...The most precious part of plasticity consisting in ability to form habits of independent judgment and of inventive initiation has been ignored." (Dewey, 1922, pp. 96-97)

Finally, let us remember, no competency-based criteria will transmit the acquired values of our society which distinguish it from other societies. It does not enable the creation of values.

SUMMARY

- Distinction can be made between learning as a training process and learning as new concept formation (development and growth).

- Training is useful in the acquisition of skills. It enlarges the automatic control mechanism field of activity.
- Machines must only present material that one is sure of so that the pupil is left the freedom essential for the formation of "art images."
- Knowledge is impossible without thinking.
- Thinking is futile without knowledge.
- Goals are to be used for focusing purposes only and not become the overriding concern in education.
- Competency based criteria are only relevant to training if they are an outgrowth of the individual's own activity.



PROCESS OF PLANNED SOCIO-TECHNICAL CHANGE

FOOTNOTES

1. Schalock, D. H., "The Focus: Knowledge, Teaching Behavior, or the Products?" pp. 43-49 in Burdin, Joel, L. and Reagan, Margaret, T., editors, ERIC Clearinghouse on Teacher Education, Dupont Circle, N.W., Washington, D.C., February, 1971

2. Emphasis not in original.

3. Duchastel, Philippe, C. and Merrill, Paul, F., "The Effects of Behavioral Objectives on Learning: A Review of Empirical Studies", in the Review of Educational Research, Winter 1973, Vol. 43, No. 1, pp. 53-69, published by the American Educational Research Association, 1126 16th Street, N.W., Washington, D.C.

4. See Appendix A

5. For a thorough going review, see John Dewey's Human Nature and Conduct, New York: Holt and Company, 1922.

6. Conversation with Mr. Herron, Division of Testing, Philadelphia Board of Education, Philadelphia, Pa.

7. Figures from the State Board of Education, Dr. Charlotte Garman, Harrisburg, Pa.

8. News HEW for release March 24, 1973 HEW - C81 RE: Child Development Association, CDA Project.

9. Weinberger, Caspar, W., HEW News Release Op. Cit., p. 1 (emphasis not in the original)

10. Paraphrasing Dean Rosner -- for a more complete account of the problems of accountability see Harry S. Broudy, The Real World of the Public Schools, NY: Harcourt, Brace and Jovanovich, Inc., 1972.

11. Based on Israel Scheffler's "Models of Teaching" in Philosophy and Education: Modern Readings. (Boston, Mass.: Allyn and Bacon, 1966) and John Dewey's critical work on How We Think. (NY: Heath and Co., 1910) Comment here based particularly on the weaknesses and strengths of the impression and insight models. Scheffler's rule model as stated in this work (1966) is more static than if it is read in the context of his other works (The Anatomy of Inquiry, et al...). Final principles are not final. The notion of what is reasonable changes, as it did for Dewey before. Thus rule model however is indicative of the kind of thinking that can be found in Kohlberg and Piaget. However, even while principles change, we need an explicative schema for discovery as well as innovation. This has been focused on by Dewey.

12. The term "error input" is an engineering term commonly accepted to mean a disturbance.

13. It is important that environment be defined here as that which is beyond the power capacity controlled by the mechanism. Anything within the controlled power capacity is to be considered as part of the system itself.

14. Dewey, 1934, p. 208

15. Definition of thinking: Analysis of doubt, of disturbance.

16. Choice as used hereafter refers to a sequence of events which is outside previously experienced patterns. It is to be distinguished from previously established response patterns or reactions.

17. We can now understand why the ERE is seemingly the only successful learning machine.

18. Kalnins, I.V. and Bruner, J.S., "Infant Sucking Used to Change the Clarity of a Visual Display", Unpublished, 1973.

19. Dewey, 1961, p. 145.

20. Dewey, 1961, p. 154.

21. If there is no concept, no new concept can evolve. If there is no understanding, there is no enhancement, there can be no new concept formation. Let it be clearly stated that one cannot be trained to understand an adapting system.

22. Supra, Art is "to select what is significant and to reject by that very same impulse what is irrelevant and thereby compressing and intensifying the significant." The essential distinction in human versus animal enhancement can be understood if one considers the action of a monkey grabbing a stick to get a banana. There is nothing involved here but a reflex action. There is no involvement of an enhancement or a distortion of the looks of a banana. All this amounts to is the eye seeing the banana and the stick (in some cases, the stick has to be pushed toward the monkey to see it), and the monkey extends his arm. In the case of the human, there would be understanding of the stick as a tool (there may be a breaking of a branch to use the stick); i.e., form the concept of using a tool. In the case of the monkey, all it is is the mechanics of the action, i.e., see then use it.

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